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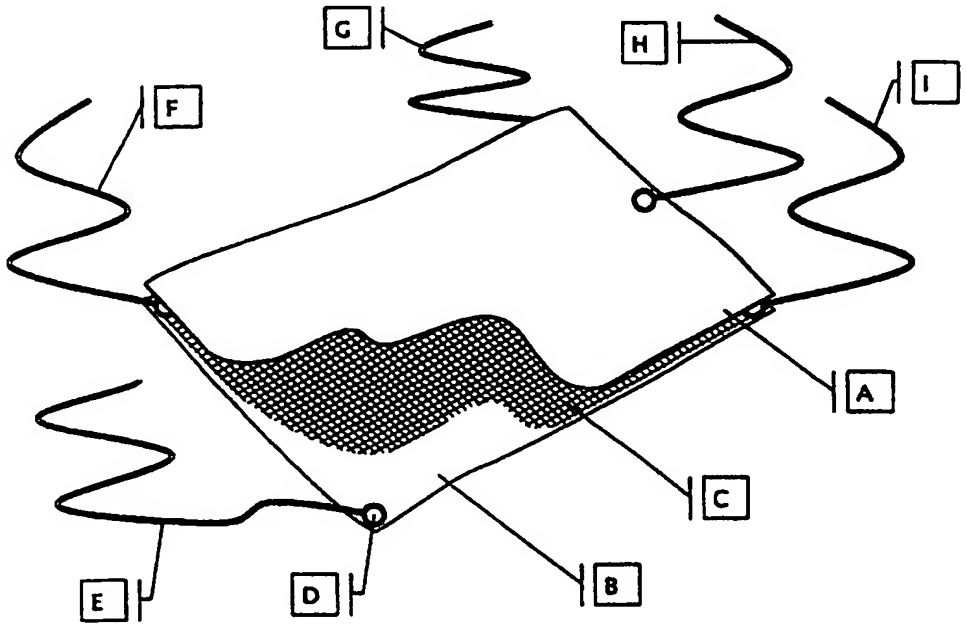
(54) Title: PRESSURE SENSOR



(57) Abstract

A sensor is formed of a plurality of conductive fabric layers (A, B) separated by an insulating layer (C). The first conductive layer (A) is provided with an electrical terminal (H) while the second conductive layer (B) is provided with a plurality of electrical terminals (E–I). Upon application of compressive pressure, electrical contact is established between the first and second conductive layers (A, B) the nature of which can be determined by analysis of the resistances between the various electrical terminals.

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PRESSURE SENSOR

The present invention relates to a pressure sensor, preferably formed from conductive fabric layers, for use, for example in determining the type of pressure applied to an area.

There are applications, for example in hospital beds, where it would be advantageous to be able to obtain an accurate indication of pressure on a patient in order to be able to minimise the risk of or to treat bed sores and the like. No known system exists for performing this function.

According to an aspect of the present invention, there is provided a sensor capable of detecting applied pressure and providing information as to the area, location and/or extent of the pressure.

The preferred embodiment provides an electrical switch and/or sensor, of largely fabric construction, capable of detecting applied pressure and providing information as to the area, location and extent of that pressure.

According to another aspect of the present invention, there is provided a pressure sensor including at least three conductive layers and at least two spacing layers interposed between the conductive layers.

The spacing layers in effect provide a two or more tier pressure sensor useful in giving an indication of the amount of pressure.

It has been found in prototype testing that the area subjected to a particular threshold pressure can be detected, together with it contour. This can be particularly useful with beds which can adjust the support for the patient to more the pressure points for the comfort of the patient and to prevent or treat bed sores.

In a preferred embodiment, fabric layers incorporating

conductive fibres or yarns, normally held apart by separator means, can be brought into electrical contact by applying pressure across the layers, to act as an electrical switch.

A practical embodiment includes at least two sheets of textile (woven or knitted) construction having electrically conductive yarns or fibres or filaments in their structure. these can be separated electrically by at least one separator layer. These layers are assembled into a sheet structure with multiple layers. The separator layer is of insulating material and can be in the form of raised bumps, a grid/mesh of any pattern, or stripes/bands. The thickness and spacing of the elements of the separator layer is such that when a certain level of pressure is applied across the thickness of the sheet assembly, electrical contact is made between the normally separate layers.

The separator means may be configured such that a pre-determined pressure is required to make contact across the assembly.

Advantageously, the separator means allow maximum flexibility and elasticity of the assembly in at least two axes without causing accidental bridging.

The invention also provides a method of measuring and interpreting electrical voltages and resistance across layers in contact, in order to obtain some information relating to the area of contact and to the position and shape of that contact:

An embodiment of the present invention is described below, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a cross-sectional view of an example of fabric pressure sensor;
Figure 2 is a perspective view of the sensor of Figure 1; and
Figure 3 shows the sensor of Figure 1 in use.

Referring to Figure 1, conductive fibres are incorporated into textile structures to form upper (A) and lower (B) conductive fabric layers. These layers are separated by an open mesh (C) formed of a flexible insulating material. The three layers (A,B,C) are assembled into a structure. The thickness of the separator layer, in combination with its scale of spacing and the flexibility of the layers determine the pressure required to make contact between the conductive layers.

Figure 2 shows electrical connections (D) which are made at one point (H) on the upper sheet (A), and at four points (E,F,G,I) on the lower sheet (B).

A (low) voltage is applied across two of the connections on the lower sheet, for example E-G. A measurement of voltage is then made at H. If the two layers are in electrical contact, a voltage will be present, which is proportional to the position of the centre of that contact along the axis E-G.

A measurement of electrical resistance is then taken between E and H. This resistance (Ra) will vary proportional to a) the position and b) the area of electrical contact between the conductive sheets. A calculation of the expected resistance (Rp) assuming the contact between the sheets to be a single point can be made using the positional information previously obtained. The area of contact between the two layers is proportional to (Rp) minus (Ra) if only a single point of contact exists.

A similar procedure is carried out for points G-H to provide further information, which can be used in calculating the shape and/or number of contacts between the sheets.

The above-mentioned steps are repeated substituting I-F for E-G. Further information is obtained in this way to further define the shape of the electrical contact. The more connection points used in this way, the greater the resolution

of the defined shape.

Information regarding the shape may be used to establish 'density of contact' between the two layers; i.e. the relative proportions of E to F in Figure 3. This will be proportional to the pressure applied across the assembly within certain limits.

Testing of a prototype sensor has given an indication of the shape of the region which is subjected to pressure above the threshold pressure to cause contact of the two conductive layers.

Assemblies similar to above example, where at least one additional conductive layer, and separator means are added are also possible. This would normally be used with separators of different thickness and/or spacing so that contact would be made between different layers at different degrees of pressure, to provide for example incremental pressure switch output.

Assemblies may also include at least two of the described layers largely created in a single pass during the weaving or knitting process.

The conductive sheets may comprise continuous conductive fibres interwoven in both directions, as in the above example, or electrically independent stripes or threads, with electrical connection points at one or both ends.

The separator layers may be in the form of raised lumps of insulating fabric or other material, which may also be incorporated into the structure of one or both of the conductive sheets. Alternatively or additionally, they may be in the form of raised bars or stripes of insulating fabric or other material, which may also be incorporated into the structure of one or both of the conductive sheets.

It is also envisaged that the separator layers could be in the

form or could include a `honeycomb' or other grid of insulating fabric or other material, which may also be incorporated into the structure of one or both of the conductive sheets; or of `drop-threads' of insulating fabric or other material, incorporated into the structure of one or both of the conductive sheets.

The assembly may have a waterproof coating or casing.

The fabric version of the sensor can be used where hard or sharp objects are undesirable, for example in toys, clothing or bedding; it is lightweight, low cost, comfortable, will conform to surfaces with compound curves (curves in up to three dimensions), versatile, may be incorporated into other fabric structures and can be made to be unobtrusive.

The disclosures in British patent application 9811021.6, from which this application claims priority, and from the abstract accompanying this application are incorporated herein by reference.

CLAIMS

1. A sensor including first and second conductive layers having predetermined resistances; an insulating separator layer; at least one electrical terminal coupled to the first conductive layer and a plurality of electrical terminals coupled in spaced relationship to the second conductive layer.

2. A sensor according to claim 1, including a voltage supply operable to apply a voltage across the second conductive layers; and resistance measuring means operable to measure the resistance between the electrical terminal of the first conductive layer and one or more of the electrical terminals of the second conductive layers.

3. A sensor according to claim 2, wherein the resistance measuring means is operable to obtain a resistance measurement from a plurality of the electrical terminals to determine a contact point between the first and second conductive layers.

4. A sensor according to claim 2 or 3, wherein the resistance measuring means is operable to obtain a plurality of resistance measurements from a plurality of the electrical terminals to determine a plurality of contact points between the first and second conductive layers.

5. A sensor according to claim 4, wherein the resistance measuring means is operable to determine the shape and/or number of contact points between the first and second conductive layers.

6. A sensor according to any preceding claim, wherein the separator layer is operable to separate electrically the first and second conductive layers from one another and to allow electrical coupling of the conductive layers upon application of a compressive force.

7. A sensor according to claim 6, wherein the separator layer is operable to allow electrical coupling of the conductive layers upon application of a compressive force above a predetermined threshold.

8. A sensor according to any preceding claim, wherein the conductive layers are formed fabric layers incorporating conductive fibres or yarns or filaments.

9. A sensor according to any preceding claim, wherein electrical terminals are located at each of a plurality of corners of the second conductive layer.

10. A sensor according to any preceding claim, including more than two conductive layers and a plurality of insulating separator layers, each separator layers being located between two adjacent conductive layers.

11. A sensor according to claim 10, wherein the separator layers provide electrical contact between their respective adjacent conductive layers at different compressive pressures.

Figure 1

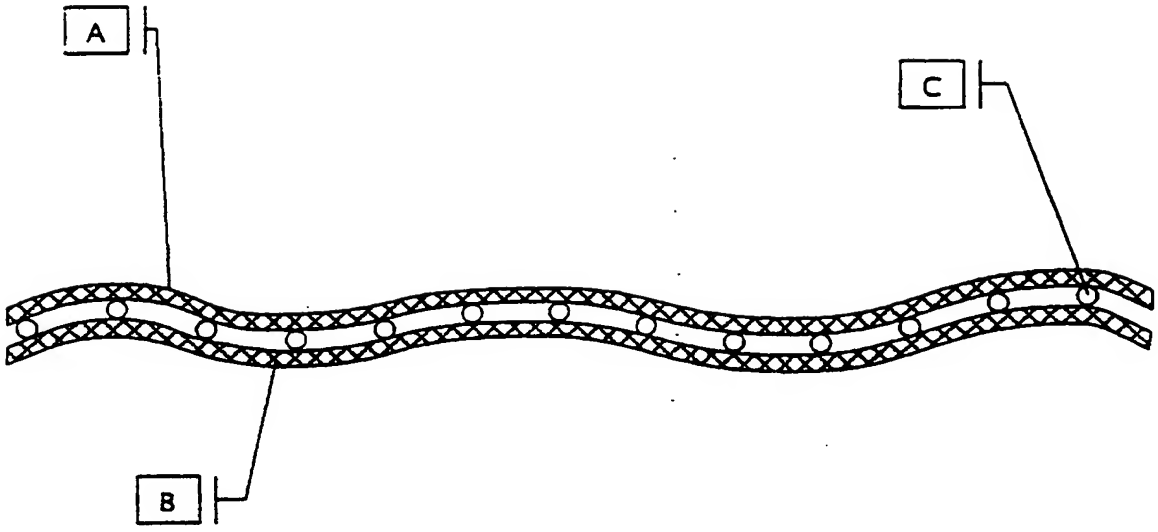


Figure 2: Cutaway View

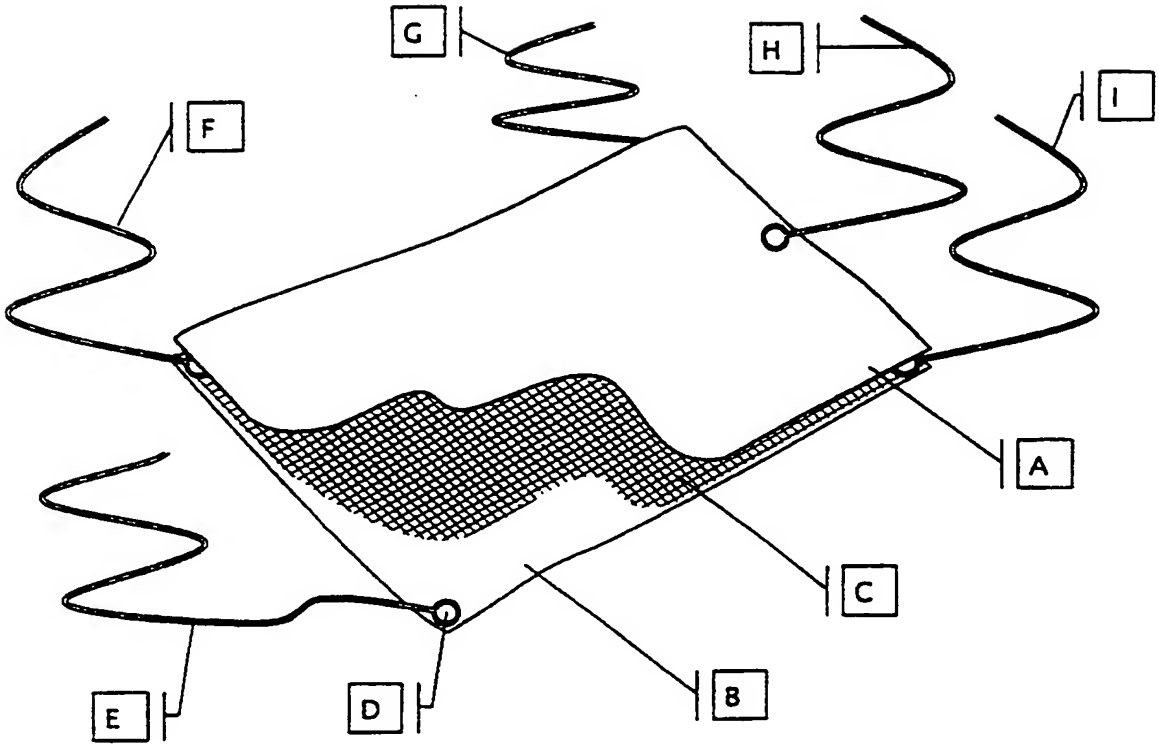
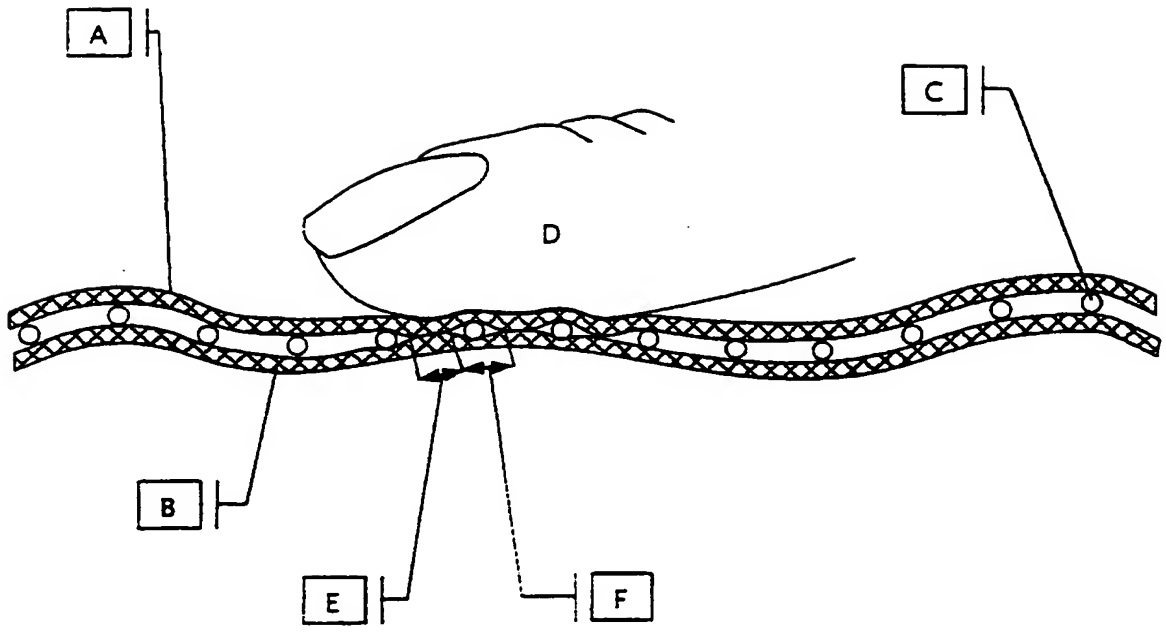


Figure 3; Cross Section in Use



INTERNATIONAL SEARCH REPORT

Inter nal Application No
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A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G01L1/20 A61B5/103 G06K11/12 G01B7/28

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G01L A61B G06K G01B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 4 933 660 A (J.R. WYNNE, JR.) 12 June 1990 (1990-06-12) abstract; figures 2,3	1-3,6,7, 9 4,5
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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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